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(54) **Cathode ray tube beam deflection amplifier system.**

(57) A cathode ray dual mode electromagnetic beam deflection amplifier system for providing current for driving a deflection coil (70), and means (40) for switching between linear and resonant non-linear operational modes. In the linear mode, the deflection coil current is controlled closely to follow an applied input deflection sweep voltage and operates as a push-pull amplifier. In the non-linear resonant mode, one-half of the output stage is abruptly decoupled from the deflection coil (70) such that energy stored in the deflection coil is discharged into a series capacitor (28), the subsequent resonant pulse being returned through the non-decoupled half of the output stage to a power supply.

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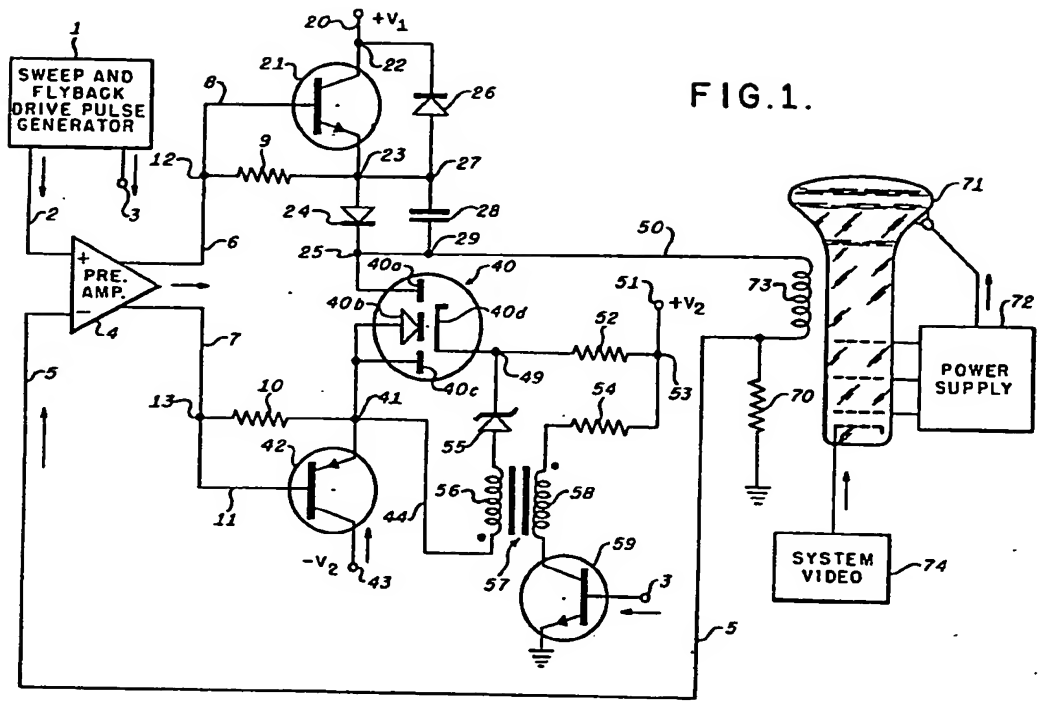

SWEEP AND FLYBACK DRIVE PULSE GENERATOR
PRE. AMP.
+V1
+V2
-V2
POWER SUPPLY
SYSTEM VIDEO
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2
3
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6
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40b
40c
40d
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FIG.1.

CATHODE RAY TUBE BEAM DEFLECTION AMPLIFIER SYSTEM

This invention relates to cathode ray beam deflection systems and more particularly to beam deflection amplifier systems employed in electromagnetic deflection systems.

One prior art deflection amplifier system of interest with respect to the present invention is disclosed in U.S. Patent Specification No. 3,816,792, this system including a differential input amplifier stage and a push-pull current controlling output stage which drives the deflection coil of the display system. A sampling resistor is connected in series with the beam deflection coil to provide a negative feed back voltage proportional to coil current for use in promoting linear operation of the system. One terminal of a capacitor is connected to the end of the beam deflection coil coupled to the input amplifier output terminal, while the other terminal of the capacitor is connected through a bidirectional switch to a voltage source. The bidirectional switch consists of a transistor and a diode connected in parallel, each constituting a respective half of the switch and operative in respective halves of the cycle of resonant oscillation which occurs during the resonant retrace interval. When the deflection amplifier system is operating in the linear mode, the bidirectional switch is non-conducting and, therefore, the capacitor is effectively disconnected from the deflection coil. In the non-linear mode, the bidirectional switch functions to connect the capacitor conductively with the beam deflection coil; simultaneously, a second switch effectively disconnects the coil-capacitor circuit from the input amplifier, whereby resonant current flow occurs between the beam deflection coil and the capacitor to effect the desired rapid, energy-saving retrace. Other prior art of interest is disclosed in U.S. Patent Specification No. 3,786,303. These prior art configurations, though they accomplish their objectives in an entirely satisfactory manner, have a common limiting defect in that the fly-back capacitor shunts the deflection coil. This fact limits the operating band width

of the circuit, increases the level of power dissipation, and increases the chances of unstable operation. While the arrangement of U.S. Patent Specification No. 3,816,792 advantageously switches the fly-back capacitor out of the circuit cyclically, complexity and parts count were undesirably increased and, of course, the shunting effect of the capacitor is not fully removed.

According to the present invention there is provided a cathode ray tube electron beam deflection control system having linear and non-linear operating modes and comprising deflection coil means and fly-back capacitor means coupled to the deflection coil means, characterised in that the system further comprises preamplifier means having an input terminal and first and second output terminals, the input terminal being responsive to an input sweep signal during the linear mode of operation, first amplifier means having input and output terminals, the input terminal being coupled to the first output terminal of the preamplifier for amplifying the current received therefrom, second amplifier means having input and output terminals, the input terminal being coupled to the second output terminal of the preamplifier for amplifying the current received therefrom, fly-back diode means having first and second terminals, the first terminal being coupled to the first amplifier output terminal for unidirectionally conducting current received from the amplifier output terminal to the fly-back diode second terminal, diode means having first and second terminals, the first terminal being coupled to a first power supply ($+V_1$) having a first voltage potential and the second terminal being coupled to the output terminal of the first amplifier means for unidirectionally coupling current to the first power supply from the diode means second terminal, the fly-back capacitor means coupled in series relationship with the diode means and in shunt relationship with the fly-back diode means and switching means responsive to an applied fly-back drive signal for coupling the second amplifier output terminal with the fly-back diode means second terminal in the linear mode of operation, and for

decoupling the second amplifier output terminal from the fly-back diode means in the non-linear mode of operation.

The present invention provides an efficient and a compact cathode ray beam deflection coil excitation system of simplified nature. As in the aforementioned prior art circuit, a preamplifier stage is provided along with a current amplifying output stage which applies excitation of the beam deflection coil. In the present invention, however, the fly-back system is now integrated directly within the current amplifier stage. As will be further described, when operating in the non-linear resonant mode, a portion of that stage that is conducting current to the deflection coil will be abruptly decoupled from the deflection coil via a switch, such that the energy stored within the deflection coil will resonantly discharge through a series connected capacitor to a power supply being used to return the fly-back current, thereby reducing the number of parts and improving performance with respect to the prior art. This integration also provides a hybrid deflection control system capable of both raster or stroke presentation.

A cathode ray beam deflection system in accordance with the present invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a wiring diagram of the system showing its electrical components and their interconnections, and

Figures 2a to 2e are graphs useful in explaining the operation of the system of Figure 1.

Figure 1 shows a cathode ray display tube 71 having a deflection coil 73 and being supplied in the usual manner from a suitable anode voltage power supply 72. The display tube 71 includes a cathode which may be fed with video signals from a video source 74. The power supply 72 is additionally arranged to activate at least one prefocussing or control grid and a focussing electrode, in the usual manner.

A deflection sweep wave generator 1 containing an internal fly-back drive pulse generator supplies the sweep wave voltage 80 of Figure 2_a_ via a lead 2 to one input of a differential preamplifier 4, and fly-back drive synchronising pulses such as those at 82 of Figure 2_c_, which control the timing of the sweep wave 80 and appear at a terminal 3 for timing the operation of a transistor 59. The sweep generator 1 also supplies the electron beam blanking pulses 83 of Figure 2_d_ for blanking the flow of beam current in the time t_3 to t_6 indicated in Figure 2_d_ when it is desired to prevent the beam from writing on the cathode ray tube phosphor. It will be understood that the power supply 72 and apparatus for forming the blanking pulses form no essential part of the present invention so that they need not be discussed in any further detail.

One end of the deflection coil 73 is coupled to ground through a current sampling resistor 70 which provides a voltage proportional to current flowing through the deflection coil 73 and which voltage is fed back as a negative feed-back signal via a lead 5 to a second input of the preamplifier 4, the inputs on leads 2 and 5 being poled as shown in Figure 1.

A first output terminal of the preamplifier 4 is coupled via a lead 6 to a junction 12 where there is found a branching circuit via a lead 8 to the base of a transistor 21 and a resistor 9 to a junction 23 and thence to the emitter of the transistor 21. The collector of the transistor 21 is coupled through junction 22 to a voltage source $+V_1$ at a terminal 20. A diode 26 is connected between a junction 22 and a junction 27 to the junction 23. Connections are also made from the junctions 23 and 27 by a diode 24, which will be referred to as the fly-back diode, and a junction 25; and by a capacitor 28, which will be referred to as the fly-back capacitor, and a junction 29 to a lead 50 for supply of deflection current to the coil 73.

A second output terminal of the preamplifier 4 is coupled by a lead 7 to a junction 13 where there is found a branching circuit via a lead 11 to the base of a transistor

42, and a resistor 10 to a junction 41 and thence to the emitter of transistor 42. The collector of transistor 42 is coupled at a terminal 3 to a source of voltage $-V_2$.

The junction 41 is coupled to the source electrode 40c of a field effect transistor 40 and also to its substrate electrode 40b, while junction 25 is coupled to the drain electrode 40a thereof. The gate electrode 40d of the transistor 40 is connected through a junction 49, resistor 52, and junction 53 to a source of voltage $+V_2$ at a terminal 51. The transistor 40 is of the n-channel, metal-oxide-semiconductor field effect type. It is a temperature stable, enhancement mode, metal-oxide-semiconductor field effect transistor (MOSFET), having the source tied to the substrate, and is obtainable, for example, from International Rectifier's Semiconductor Division, 233 Kansas Street, El Segundo, California 90245.

The gate electrode 40d of the transistor 40 is also connected through the junction 49, a Zener diode 55, a first winding 56 of a transformer 57 (poled as shown), and a lead 44 to the junction 41 of the emitter of transistor 42. The circuit is completed through the resistor 52, junction 53, resistor 54, and the second transformer winding 58 (poled as shown). As noted, fly-back drive pulses applied to the terminal 3 from the sweep and fly-back drive pulse generator 1 are supplied to the base terminal of transistor 59 which is coupled to the terminal 3; the collector of the transistor 59 is coupled to the end of the winding 58 opposite resistor 54, while its emitter is grounded.

During the cathode ray beam sweep time t_1 to t_3 of wave 80 of Figure 2a, the transistor 59 is held non-conducting by the absence of a fly-back drive pulse 82 of Figure 2c on terminal 3. The transistor 40, however, is biased into its conducting state by the positive gate-to-source electrode voltage which consequently develops across the Zener diode 55, due to the small bias current flowing from the $+V_2$ voltage source at terminal 51 through the resistor 52, Zener diode 55, transformer secondary 58,

and transistor 42, to the $-V_2$ power supply terminal 43. The secondary 58 of the pulse transformer 57 behaves as a d.c. short circuit. As long as the transistor 40 conducts, the invention operates as a conventional linear, or stroke, push-pull amplifier. The effects of the forward voltage drop across the fly-back diode 24 and transistor 59 are compensated in a conventional manner by setting up appropriate bias voltages in the output stage of the preamplifier 4, the output signals therefrom being in phase but displaced from each other by the aforesaid bias voltages. As a result, a minimum of cross-over distortion occurs at the output 50 of the amplifier system.

At the start of time t_1, the waveform 80 is positive with respect to ground, and the transistor 21 is on, amplifying the sweep signal received from the preamplifier 4 via the lead 6, and permitting current to flow from the $+V_1$ power supply at terminal 20 through the transistor 21, diode 24, deflection coil 73 and resistor 70 to ground. The transistor 42 is biased to conduct current when the sweep generator output signal received from the preamplifier 4 via lead 7 approaches zero volts at time t_2, from the $-V_2$ power supply at terminal 43, through transistor 40, deflection coil 73, and resistor 70, to ground.

At the start of the fly-back time t_3, deflection current is flowing through the transistor 42. The transistor 59 is made to conduct by a fly-back drive pulse applied at terminal 3 to its base electrode. The conduction of transistor 59 causes a voltage drop across the primary winding 58 of transformer 57 so that a corresponding rapid voltage change obtains across the transformer winding 56. This latter impulse pulls the gate-to-source voltage of the transistor 40 negative causing it to become reverse biased, abruptly ending conduction therein. In this manner, the current path of the deflection wave 81 changes at time t_3 and a new current path is used. The current in the coil 73 can no longer flow through the transistor 42 and instead flows through the fly-back

capacitor 28 and diode 26 into the supply of $+V_1$ voltage at terminal 20.

The sudden change in current generates a positive voltage pulse according to the equation:

$$V = L \frac{di}{dt}$$

where L = the deflection coil inductance,
V = the voltage on the coil,
di/dt = the change in deflection coil current with time.

Consequently, a half cycle 85 (Figure 2e) of a resonant sinusoidal oscillation is initiated in the effective inductance of the deflection coil 73 together with the capacitance of the fly-back capacitor 28, and appears as a fly-back pulse on lead 50.

As the current shown by waveform 81 in Figure 2b flows through the deflection coil 73, it will decrease in amplitude from the negative maximum reached at time t_3, until it falls to zero volts at time t_4, in correspondence with the fly-back pulse 85 peak, and reverses, thereby becoming positive. Reverse current will now flow from the $+V_1$ power supply at terminal 20 and through the transistor 21 and the fly-back capacitor 28 until the voltage across the latter rises to a point where it will forward bias the diode 24 into conduction. The diode 24 thus acts as a clamping diode and prevents the current from ringing negatively. At this time, t_5, the transistor 59 is turned off by the ending of pulse 82 and the transistor 40 is again biased into conduction. The operation of the invention becomes linear again, comparing the inputs on leads 2 and 5 to correct for any error between the voltage at the input of the pre-amplifier 4 on lead 2 across the sampling resistor 70 in the manner of a conventional amplifier using negative feed back. As long as the transistor 40 remains conducting, the invention behaves as a linear or stroke type of amplifier. Thus, the invention desirably operates to convert the input drive voltage on the lead 2 to a proportional current flowing through the deflection coil 73.

It is seen that the invention provides a simplified electron beam deflection control system of compact nature which permits hybrid operation with a reduced number of parts. The fly-back capacitor 28 does not shunt the yoke inductance 73 during linear operation so that the operating bandwidth is increased and the cathode ray trace is sharper. The fly-back capacitor 28 is also desirably not switched in and out of circuit thus not requiring the additional switching circuits of the prior art. Furthermore, stability is improved because the fly-back capacitor 28 is no longer grounded, eliminating the potential of a typical emitter-follower parasitic oscillation problem. Quicker recovery after the fly-back interval is achieved without the use of appreciably higher power.

Claims

1. A cathode ray tube electron beam deflection control system having linear and non-linear operating modes and comprising deflection coil means and fly-back capacitor means coupled to the deflection coil means, characterised in that the system further comprises preamplifier means (4) having an input terminal and first and second output terminals, the input terminal being responsive to an input sweep signal during the linear mode of operation, first amplifier means (21) having input and output terminals, the input terminal being coupled to the first output terminal of the preamplifier (4) for amplifying the current received therefrom, second amplifier means (42) having input and output terminals, the input terminal being coupled to the second output terminal of the preamplifier (4) for amplifying the current received therefrom, fly-back diode means (24) having first and second terminals, the first terminal being coupled to the first amplifier output terminal for unidirectionally conducting current received from the amplifier output terminal to the fly-back diode second terminal, diode means (26) having first and second terminals, the first terminal being coupled to a first power supply ($+V_1$) having a first voltage potential and the second terminal being coupled to the output terminal of the first amplifier means (21) for unidirectionally coupling current to the first power supply from the diode means second terminal, the fly-back capacitor means (28) coupled in series relationship with the diode means (26) and in shunt relationship with the fly-back diode means (24), and switching means (40) responsive to an applied fly-back drive signal for coupling the second amplifier (42) output terminal with the fly-back diode means (24) second terminal in the linear mode of operation, and for decoupling the second amplifier output terminal from the fly-back diode means in the non-linear mode of operation.

2. A system according to claim 1, characterised in that the first amplifier means comprises a first transistor (21) having a base coupled to the first output terminal

of the preamplifier means (4), a collector coupled to the first voltage supply means ($+V_1$) and an emitter coupled to the first terminal of the fly-back diode means (24), and the second amplifier comprises a transistor (42) having a base coupled to the second output of the preamplifier (4), an emitter coupled to the switching means (40) and a collector coupled to a second voltage supply ($-V_2$).

3. A system according to claim 1 or 2, characterised in that the switching means comprises a third transistor (40) having source, drain, and gate electrodes (40c, 40a, 40d) the source electrode (40c) being coupled to the output of the second amplifier (42), and the drain electrode (40a) being coupled to the second terminal of the fly-back diode (24), a transformer (57) having primary and secondary windings (58,56), a first series circuit coupled between the gate and source electrodes (40d, 40c) of the third transistor (40) comprising a Zener diode (55) and the secondary winding (56) of the transformer (57), a resistor (52) coupled between the junction of the gate electrode (40d) and the Zener diode (55) and a third power supply ($+V_2$), and a second series circuit coupled between the third power supply ($+V_2$) and a ground terminal comprising a fourth transistor (59) having its emitter coupled to the ground terminal, its collector coupled to the transformer primary winding (58), and its base coupled to receive the fly-back drive pulses, whereby the third transistor means (40) will substantially cease conduction in response to the fly-back drive pulses applied to the fourth transistor means (59).

4. A system according to claim 3, characterised in that the second series circuit further comprises a resistor (54) coupled between the transformer secondary (58) and the third power supply ($+V_2$).

5. A system according to any of the preceding claims, characterised in that the preamplifier means comprises a differential amplifier (4) having first and second inputs, the first input being responsive to the sweep signal, and further comprising an impedance (70) connected in series with

the deflection coil (73) for providing a voltage representative of the current flowing therethrough to be fed back to the second input of the differential amplifier for comparison with the sweep signal input to derive an error signal equal to the difference between the input and feedback signals for controlling the current supplied by the preamplifier means in the linear mode.

6. A system according to claim 2 and any claim appended thereto, characterised in that the first and second transistors (21,42) are selected to be complementary symmetrical, the first and third voltage supplies ($+V_1$,$+V_2$) have a positive polarity, and the second voltage supply ($-V_2$) has a negative polarity.

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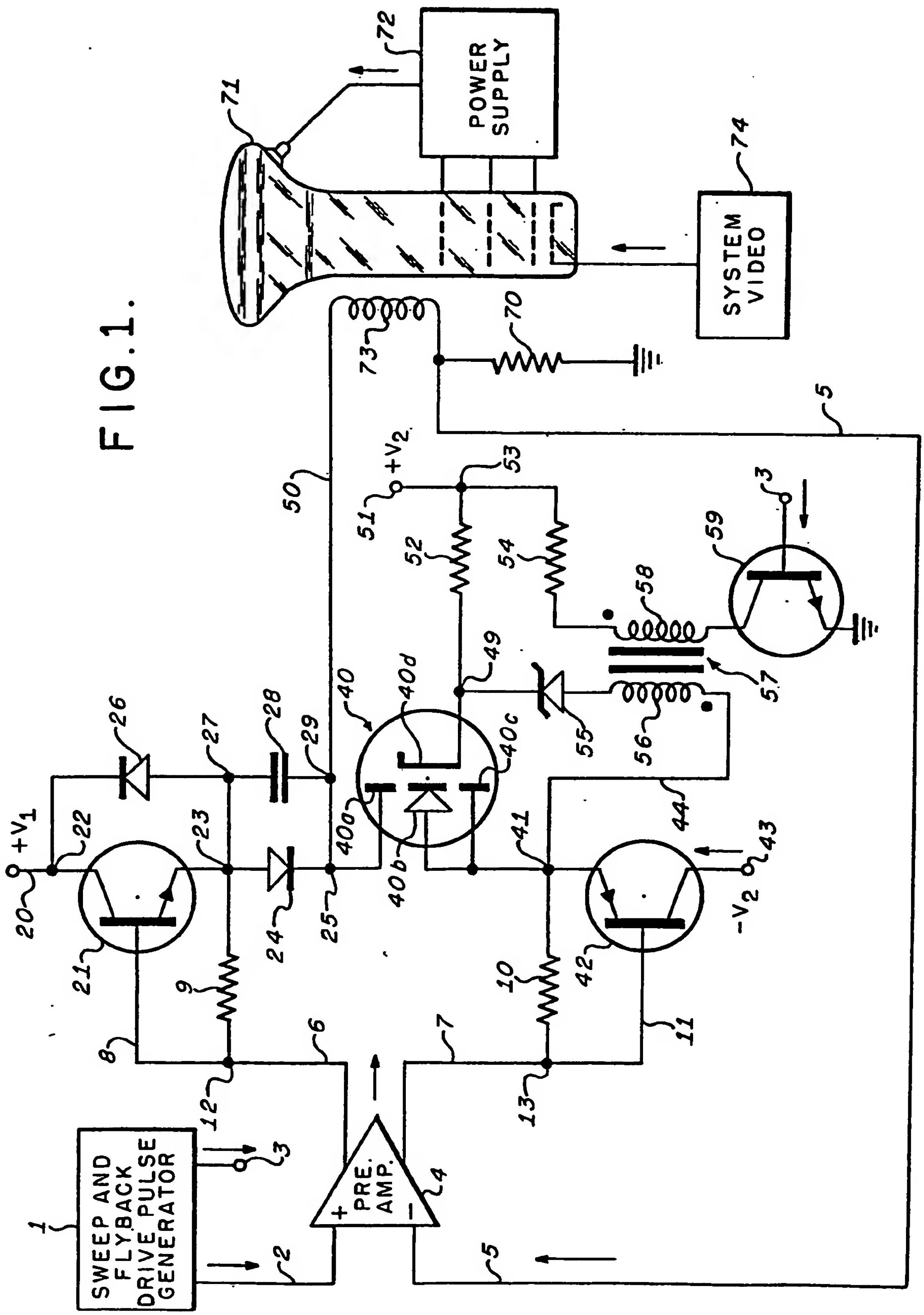

FIG.1.

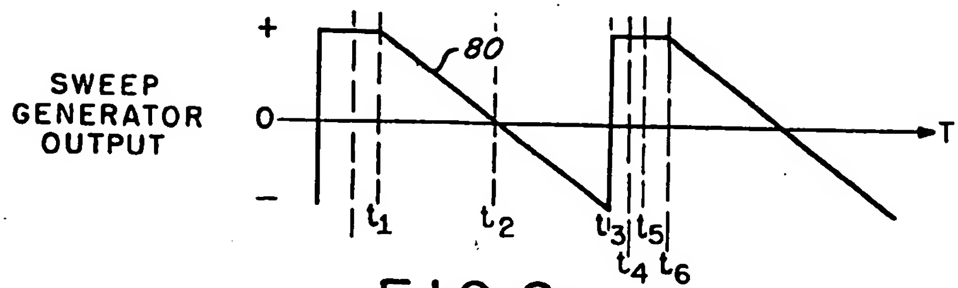

FIG.2a.

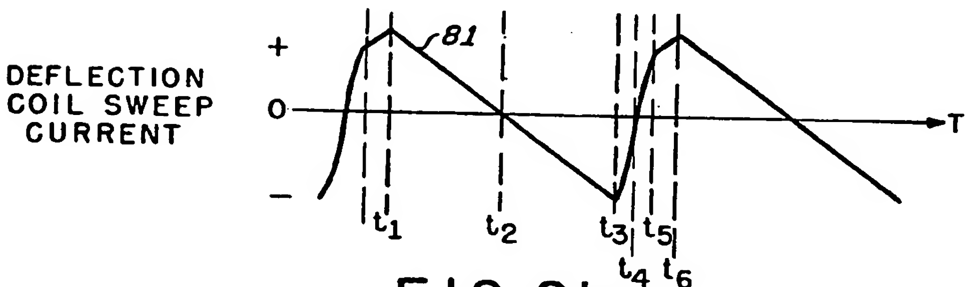

FIG.2b.

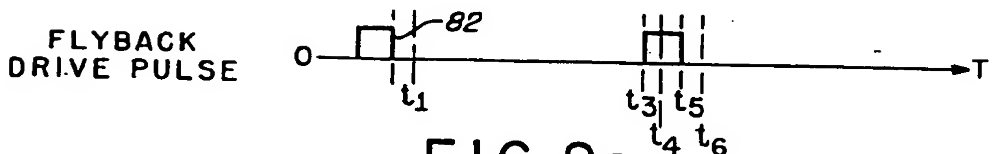

FIG.2c.

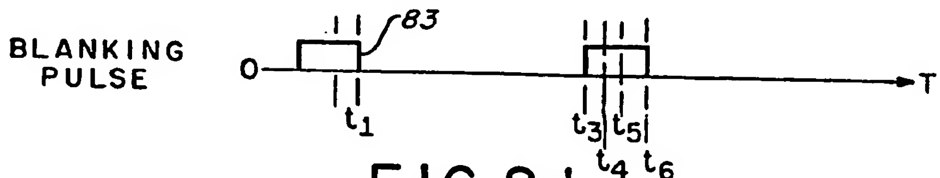

FIG.2d.

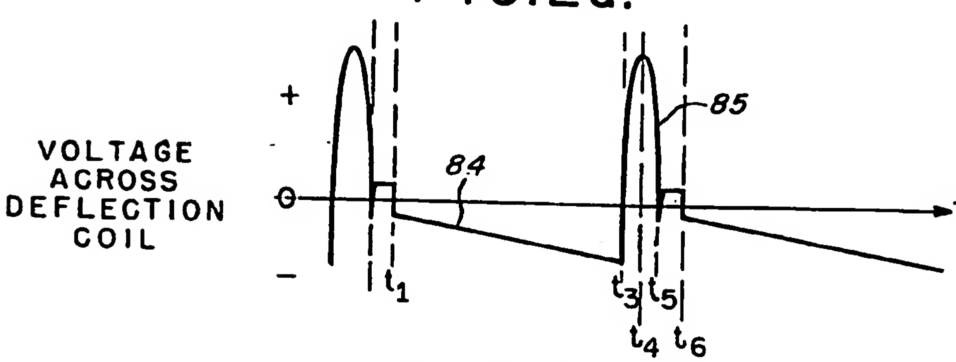

FIG.2e.